

## **Meteorological Sensor Data Files**

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### **1. Introduction**

Meteorological data at a site are of value to all space geodetic techniques. It does not make sense to have duplicate records when the same data are shared. If the measurements of each met sensor are treated as observations and recorded as separate records, complete with uncertainties, the information can be included in the analysis with appropriate statistics. For example, if the same data are used in a combined analysis, the correlation among techniques can be easily included, as can correlations with other corrections, such as thermal deformation.

In this memo I discuss some of the problems associated with making use of met data, and I propose a simple strawman format for met data files.

### **2. Issues**

Many issues should be addressed if the meteorological data are to be incorporated in the geodetic analysis in a rigorous way.

#### **A. Measurement uncertainty**

The uncertainty in the met instrument measurement has a spectrum, as do all measurements, ranging from the expected repeatability for a succession of samplings to the likely change in mean value over a long period of time. As a first step, since most analysis packages do not have a way to make use of a spectrum, it may be convenient to characterize the measurement uncertainty by two numbers, the per-observation uncertainty and the calibration uncertainty, representing the long-term error. The calibration uncertainty may grow with time since the last calibration.

#### **B. Calibration**

Since the mean values of the met instrument will change with time, or the instruments might need to be repaired or replaced, calibration will be necessary. Each occurrence will require the entry of a value at least for the new calibration if not also for the end of the previous calibration period. Several questions arise:

1. How to calibrate?
  - a. Bring calibration set to the site
  - b. Remove met sensors and send away for calibration
  - c. Compare with nearby “good” instrument, e.g., at closest airport
  - d. Compare with Numerical Weather Product
2. How often to calibrate?

3. Should the readings of the instruments be corrected or should the correction (or error) at the time of calibration be recorded for use at the time of analysis?
4. What to do if met sensors fail and have to be changed?  
i.e. how to interpolate between calibrations

#### C. Corrections

There are at least two types of corrections that will need to be made for the met sensor values:

1. Correction for (interpolated?) calibration value
2. Correction from the position of the met sensor (pressure or temperature) to the reference point, e.g. intersection of axes for VLBI

In order to maintain only one data source for all techniques **the measurement file for each instrument must include both a name and the geocentric position of the instrument**. The position must have sufficient accuracy such that the transfer of the measurement to the reference point does not introduce an error of more than, e.g., 0.5 mm in the position of the geodetic instrument (VLBI, GPS, etc). One important benefit of providing this information is the potential use of multiple sensors at a site. For example, multiple temperature sensors are provided at Onsala embedded in the VLBI antenna pedestal inside the radome for correction of thermal effects, while the GPS and other systems will need the outside temperature.

#### D. Format

Each instrument (pressure, temperature, relative humidity, ceilometer) should have a separate data record. A simple self-contained file for pressure or temperature might have the following format:

```
westford_pressure_1.txt
Name epoch hh mm value sig cal_corr'n sigma X Y Z
w_p1 20060111 23 05 1004.5 0.2 0.9 0.5 6378000.0 4577000.0 1200000.3
w_p1 20060112 00 05 998.5 0.2 1.2 0.5 6378000.0 4577000.0 1200000.3
w_p1 20060112 00 10 997.4 0.2 1.2 0.5 6378000.0 4577000.0 1200000.3
w_p1 20060112 01 10 990.4 0.2 1.2 0.5 6377999.0 4576999.0 1200001.3
```

Some possible storage formats are:

1. Continuous time-tagged, as above
2. metex (rinex-like)
3. NetCDF
4. Name-list

#### E. Application of met data in the estimation process

With the met observations available in a suitable storage format, it is still necessary to interpolate to the times of the observations and import the data into the estimation process. Regardless of how this is done, provision must be made for later correction of the information due to additional or improved calibration.